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Kodaira

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(54) **SEMICONDUCTOR DEVICE
MANUFACTURING METHOD**

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application No. PCT/JP2012/071440 on Aug. 24,
2012, now Pat. No. 9,078,355.

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H01L 23/31 (2006.01)
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H01L 23/29 (2006.01)
H01L 21/56 (2006.01)
H01L 29/66 (2006.01)

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(2013.01); **H01L 23/147** (2013.01); **H01L**
23/29 (2013.01); **H01L 23/315** (2013.01);

H01L 23/3121 (2013.01); **H01L 23/3142**
(2013.01); **H01L 29/66325** (2013.01); **H01L**
23/053 (2013.01); **H01L 23/10** (2013.01); **H01L**
23/34 (2013.01); **H01L 23/36** (2013.01); **H01L**
23/49811 (2013.01)

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CPC H01L 21/56; H01L 23/10; H01L 23/34;
H01L 23/36; H01L 23/053; H01L 23/49811;
H01L 25/07; H01L 25/18; H01L 2924/00;
H01L 2924/0002

See application file for complete search history.

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Primary Examiner — Peniel M Gumedzoe

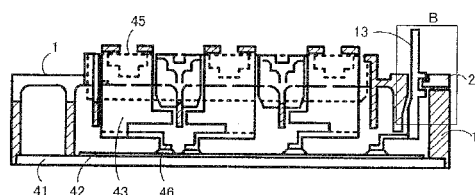
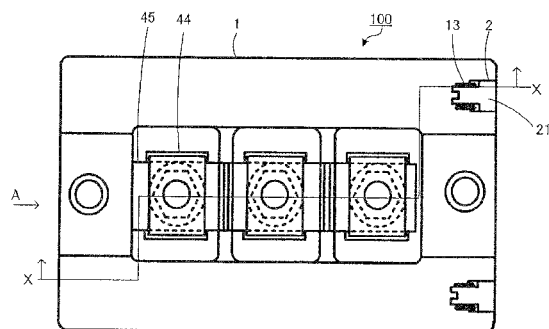
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(57)

ABSTRACT

A method of manufacturing a semiconductor device, includes
the steps of passing a control terminal through an opening of
a resin case to partially expose the control terminal and cover-
ing a patterned insulating substrate with the resin case;
inserting a resin block in the opening of the resin case; fitting
a convex step portion formed on a side surface of the resin
block into a valley formed between two projections of the
control terminal; fitting a projection formed on the side sur-
face of the resin block into a concave portion formed on a
sidewall of the opening of the resin case; and fitting a projec-
tion formed on a bottom surface of the resin block into a
concave portion formed in a beam portion at a bottom portion
of the opening of the resin case to position and fix the control
terminal.

5 Claims, 15 Drawing Sheets



(51)	Int. Cl.		<i>H01L 23/498</i>	(2006.01)
	<i>H01L 23/34</i>	(2006.01)	<i>H01L 23/053</i>	(2006.01)
	<i>H01L 23/10</i>	(2006.01)	<i>H01L 23/36</i>	(2006.01)

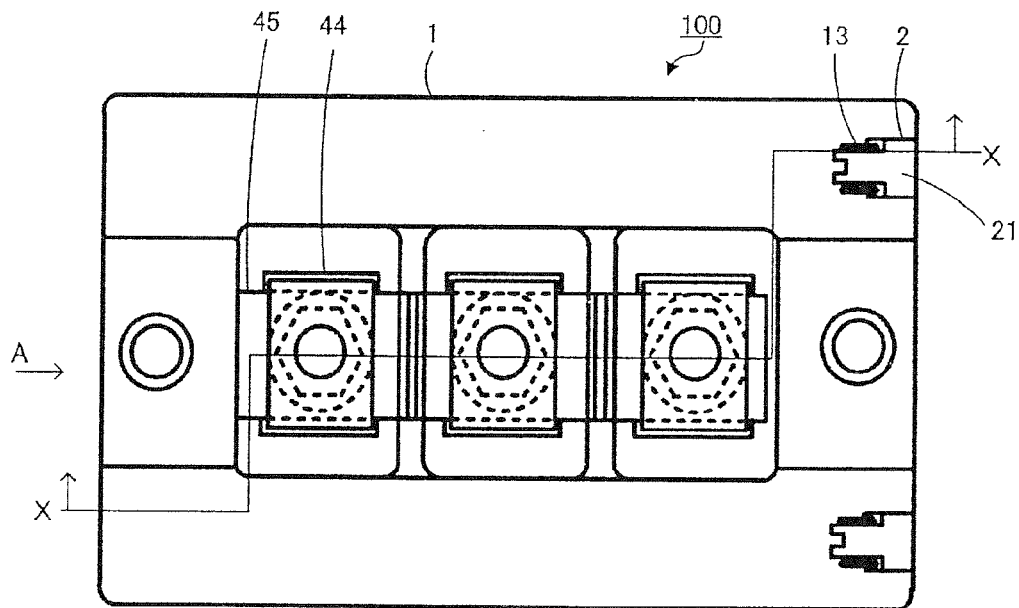


Fig. 1(a)

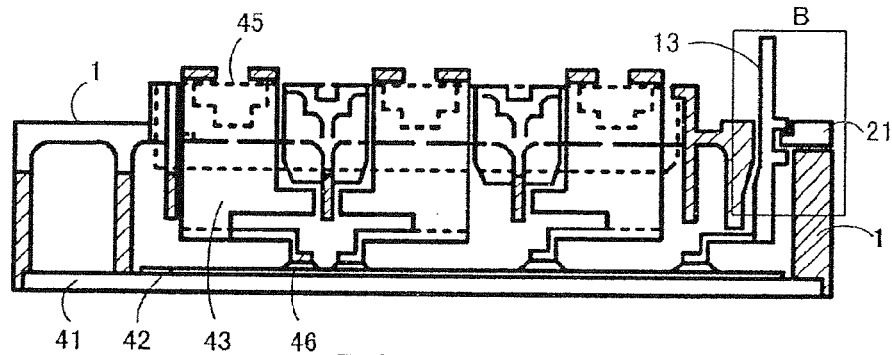


Fig. 1(b)

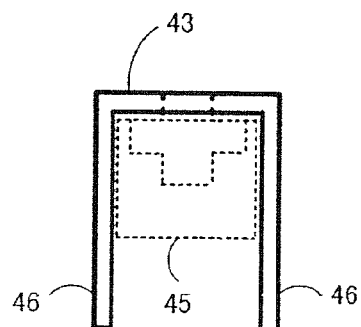


Fig. 1(c)

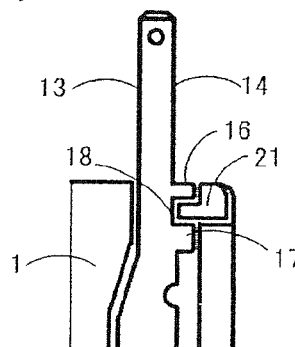


Fig. 1(d)

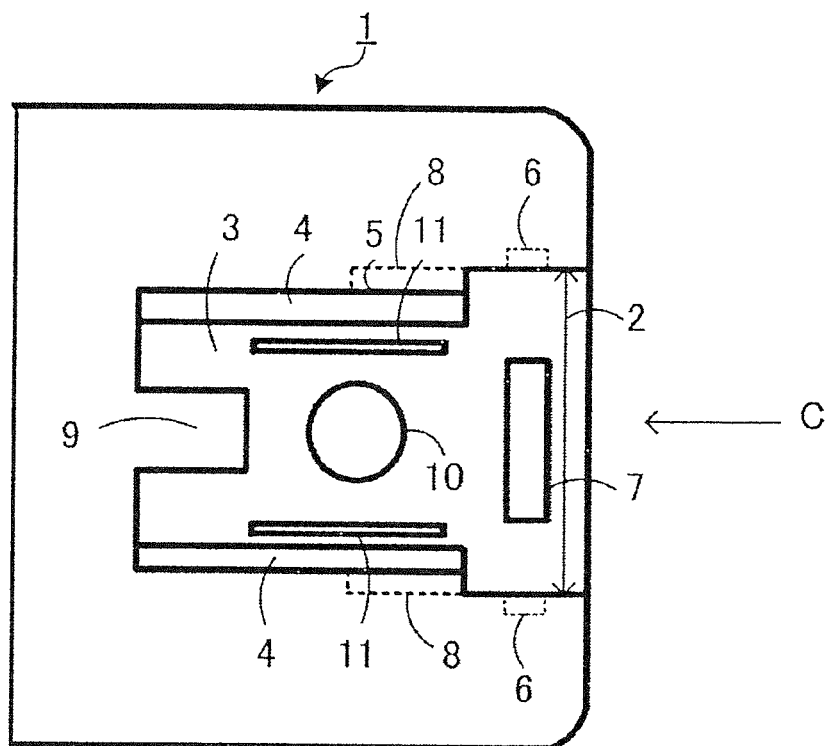


Fig. 2(a)

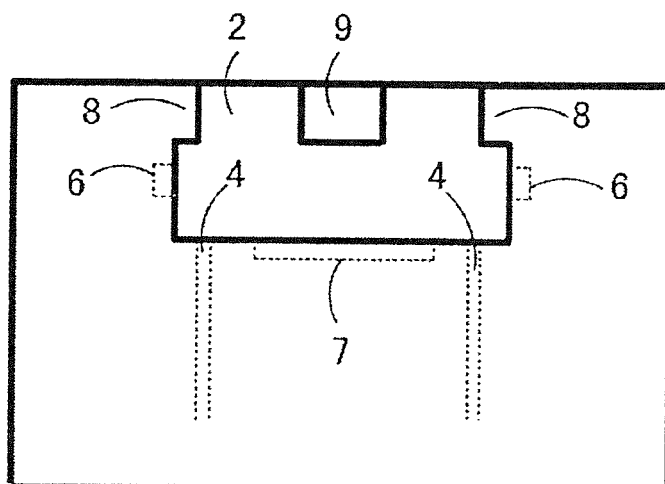


Fig. 2(b)

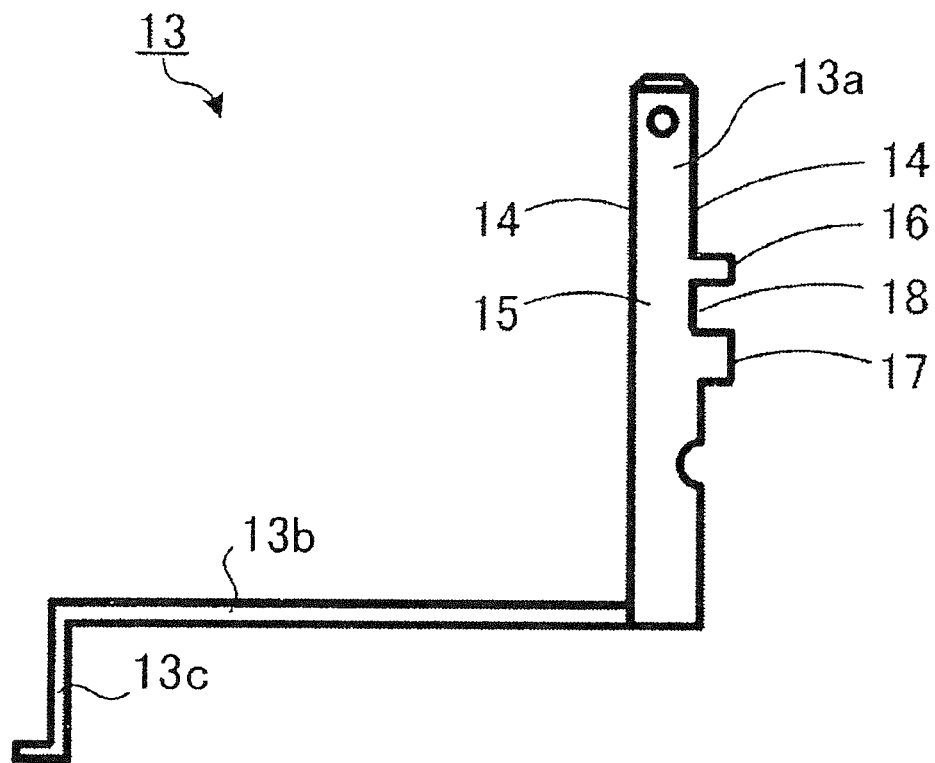


Fig. 3(a)

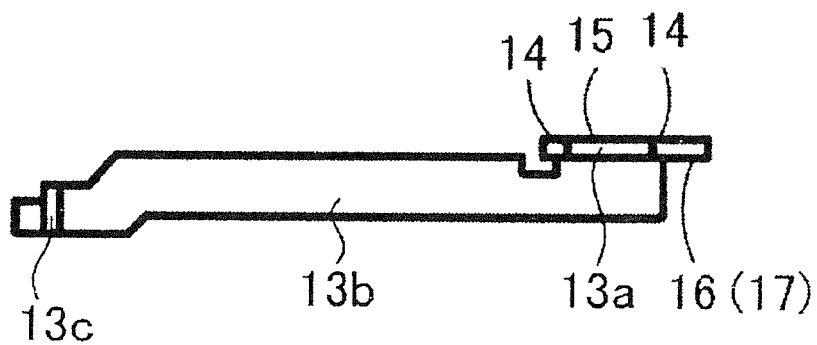


Fig. 3(b)

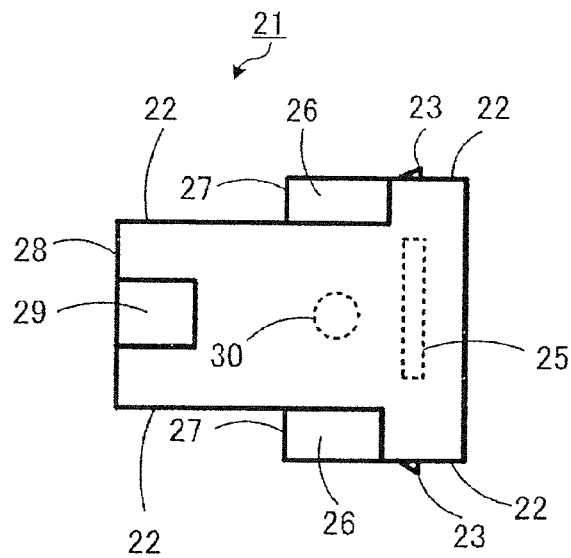


Fig. 4(a)

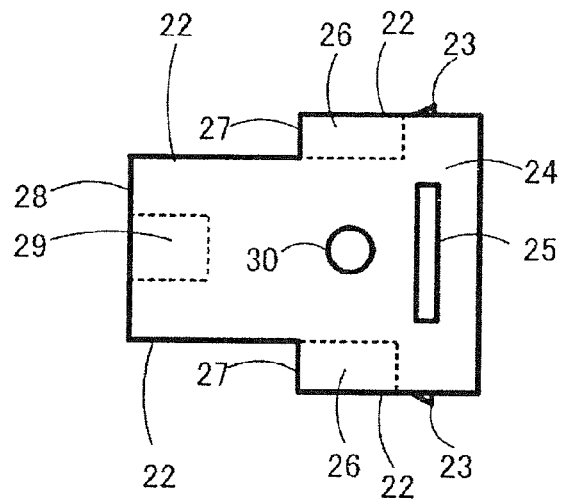


Fig. 4(b)

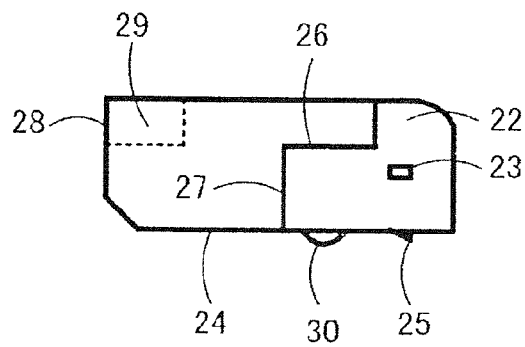


Fig. 4(c)

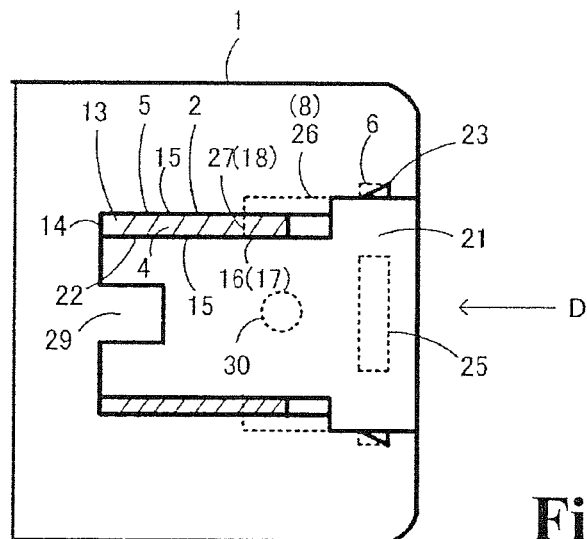


Fig. 5(a)

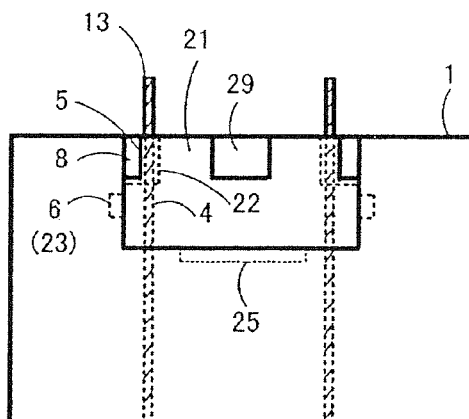


Fig. 5(b)

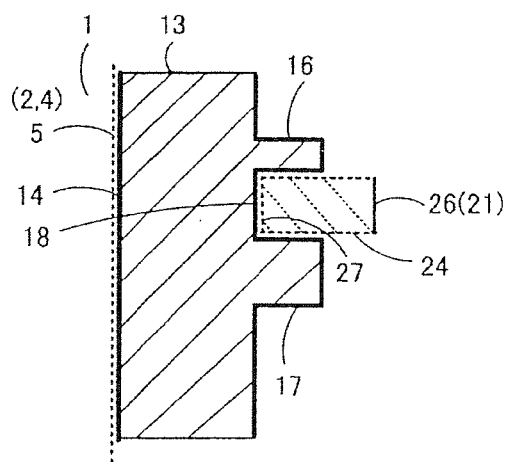
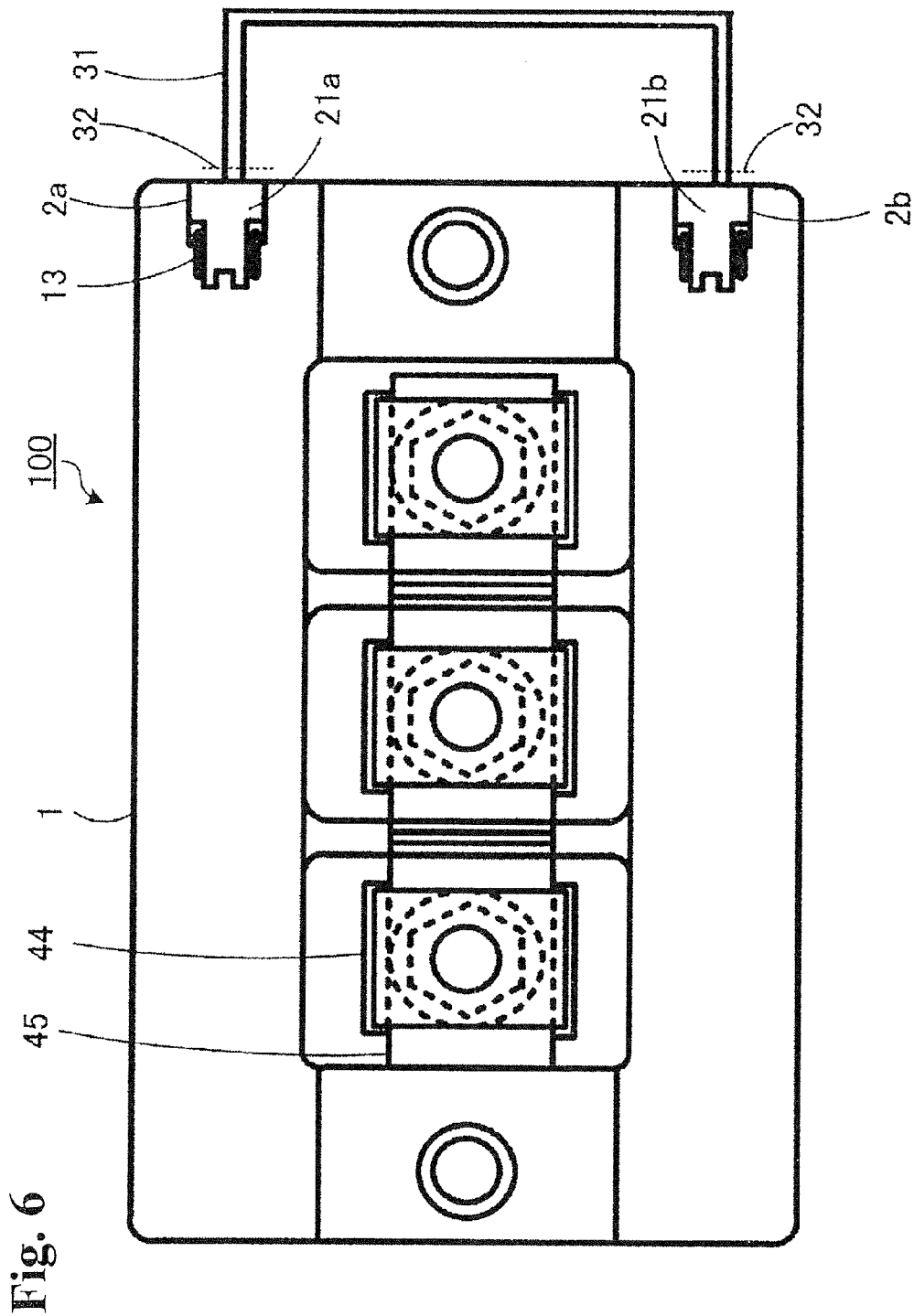


Fig. 5(c)



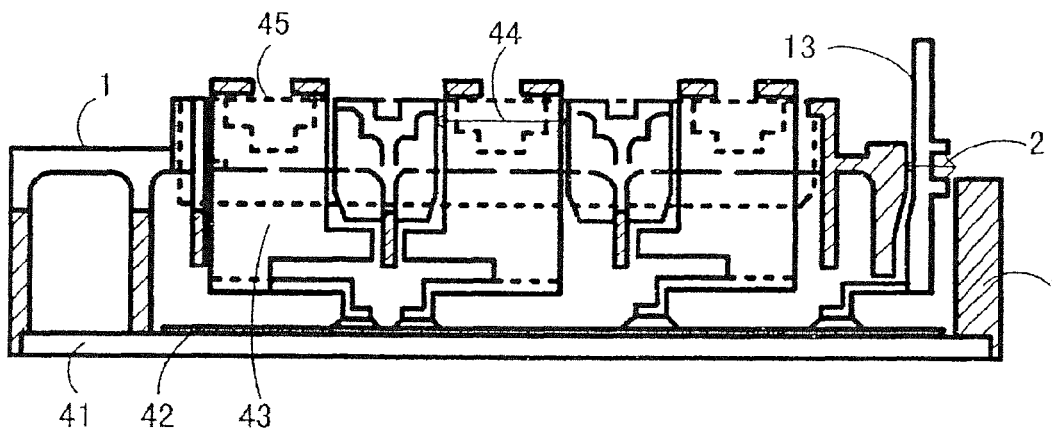


Fig. 7(a)

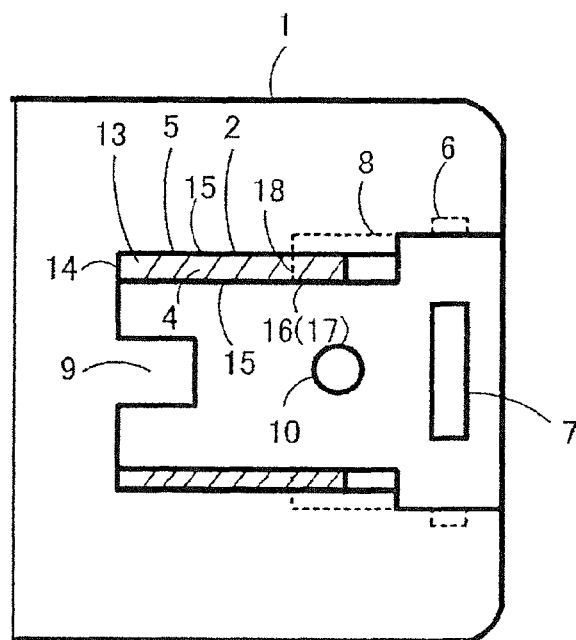


Fig. 7(b)

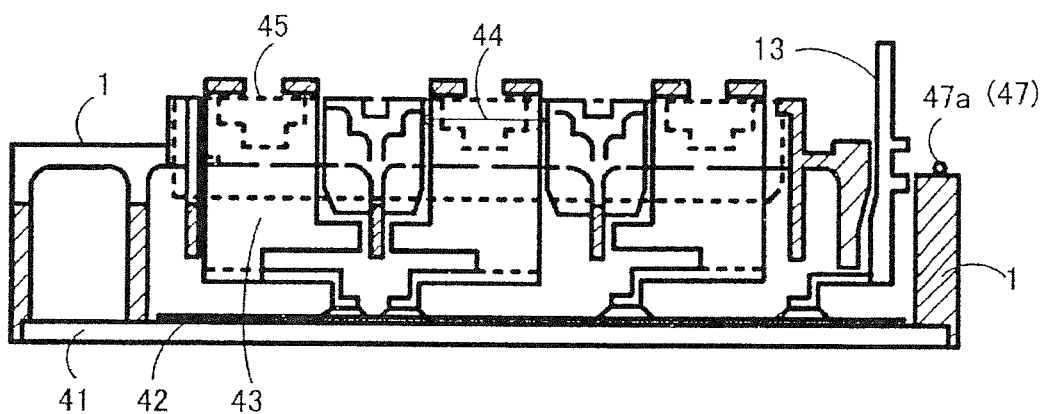


Fig. 8(a)

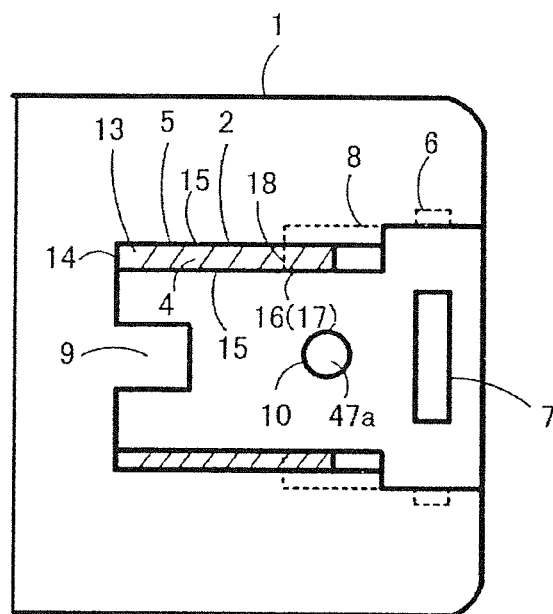


Fig. 8(b)

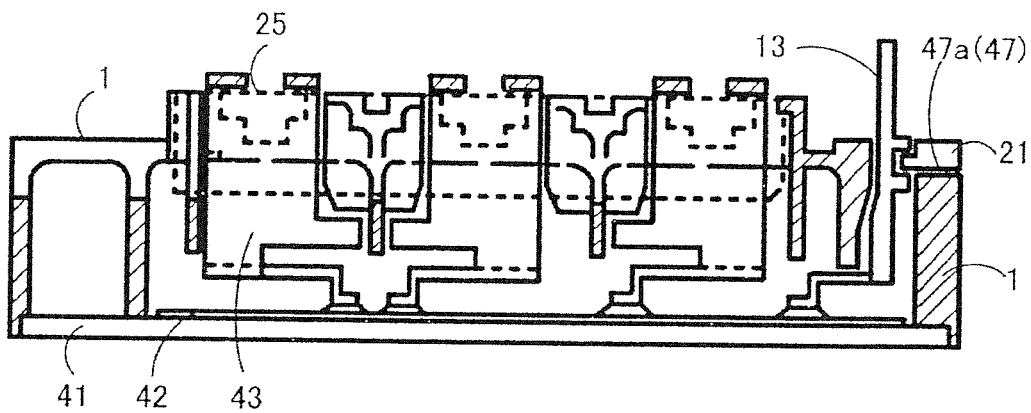


Fig. 9(a)

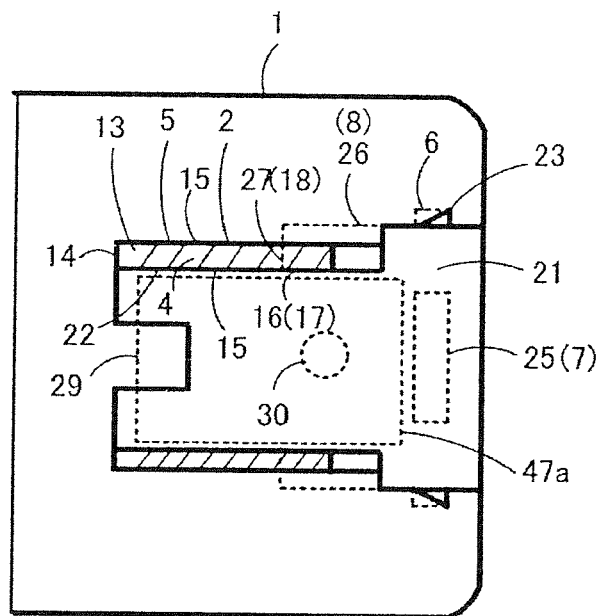


Fig. 9(b)

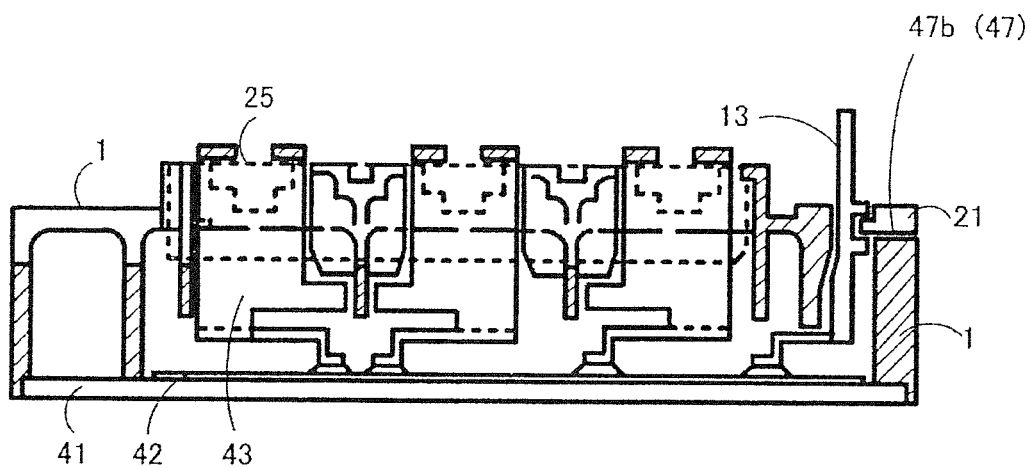


Fig. 10(a)

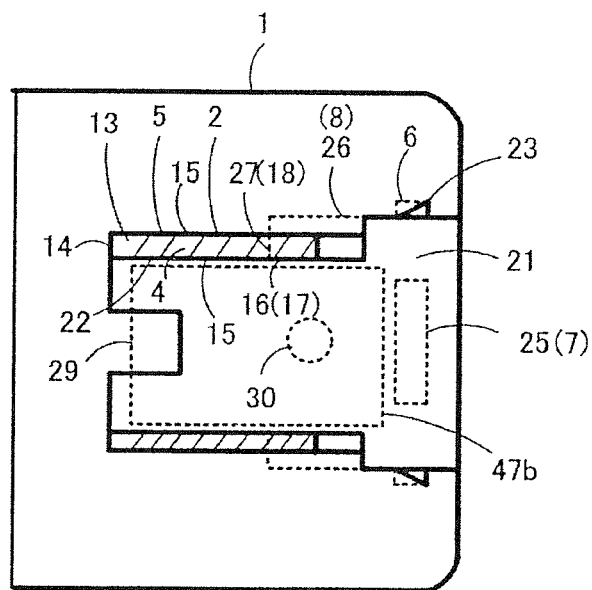


Fig. 10(b)

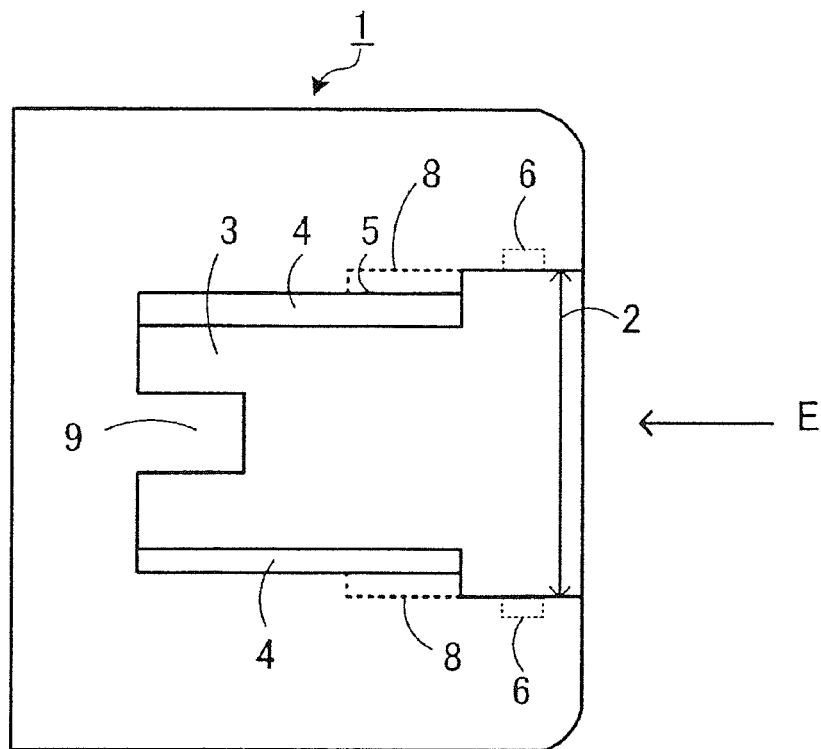


Fig. 11(a)

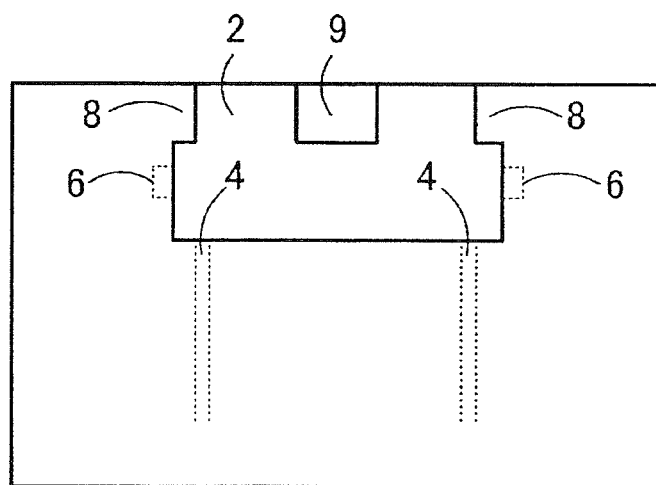


Fig. 11(b)

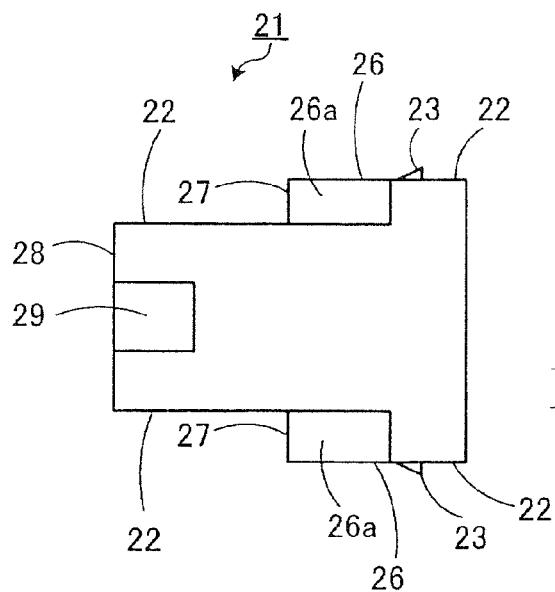


Fig. 12(a)

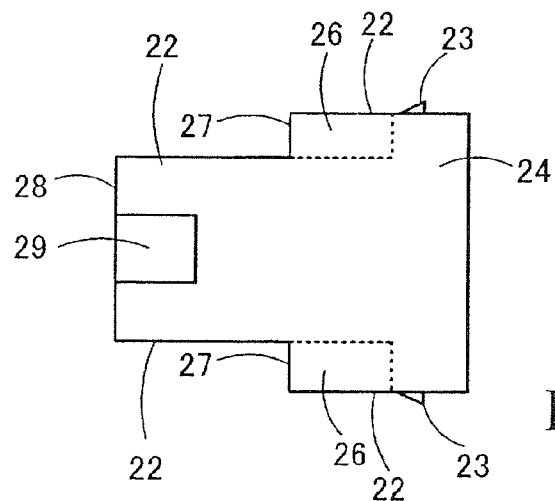


Fig. 12(b)

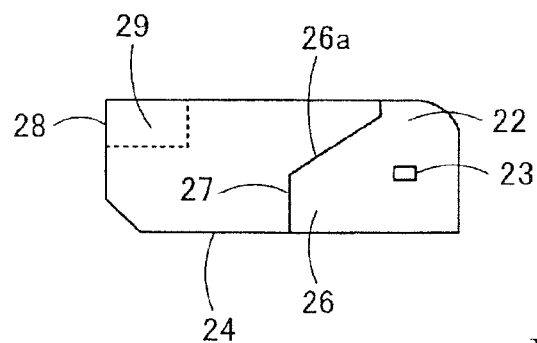


Fig. 12(c)

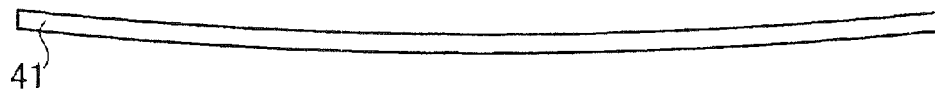


Fig. 13

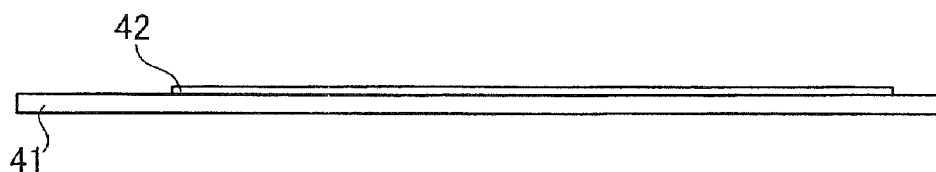


Fig. 14

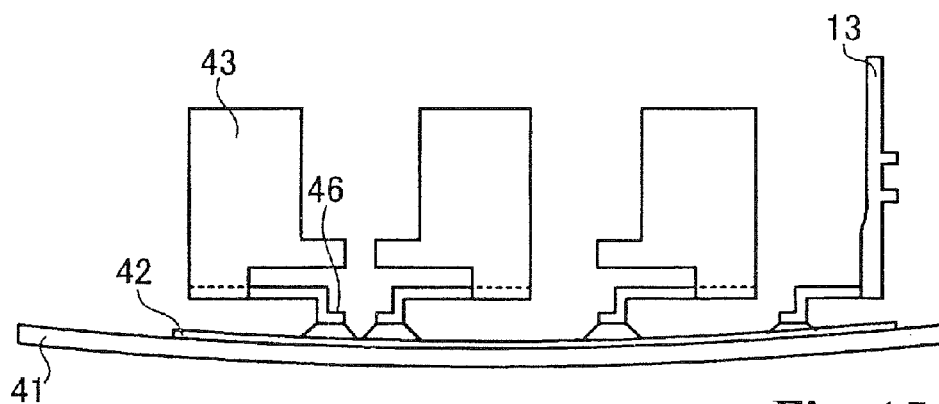


Fig. 15

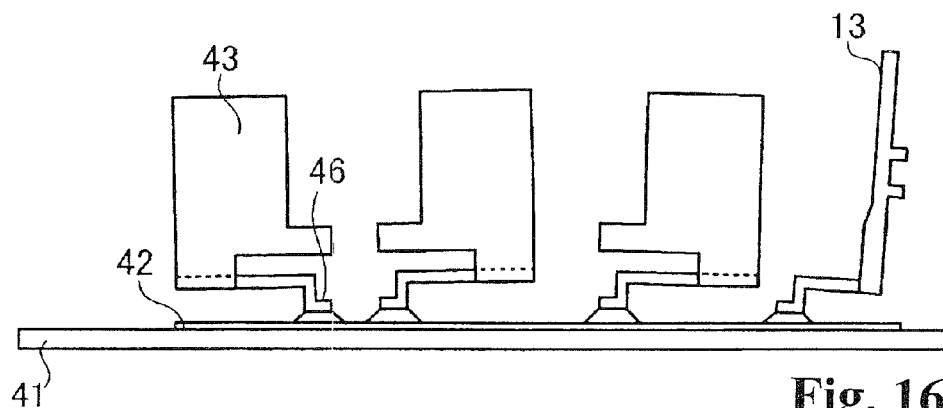


Fig. 16

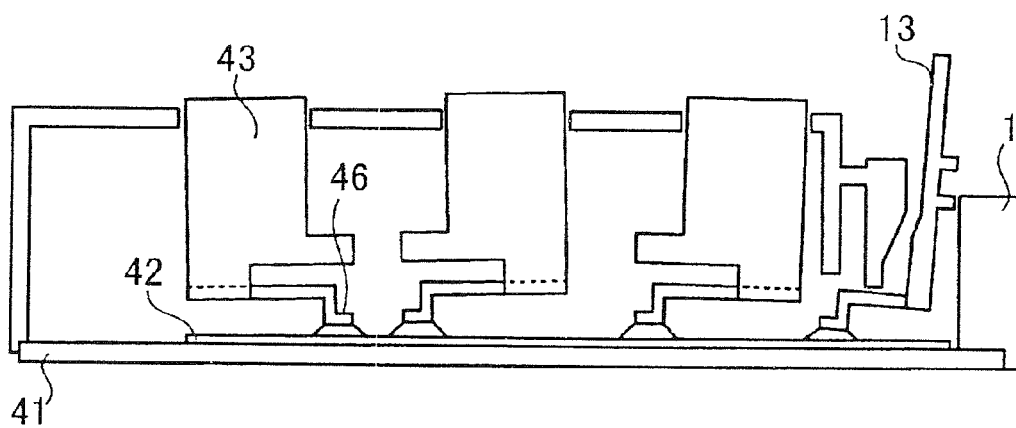


Fig. 17

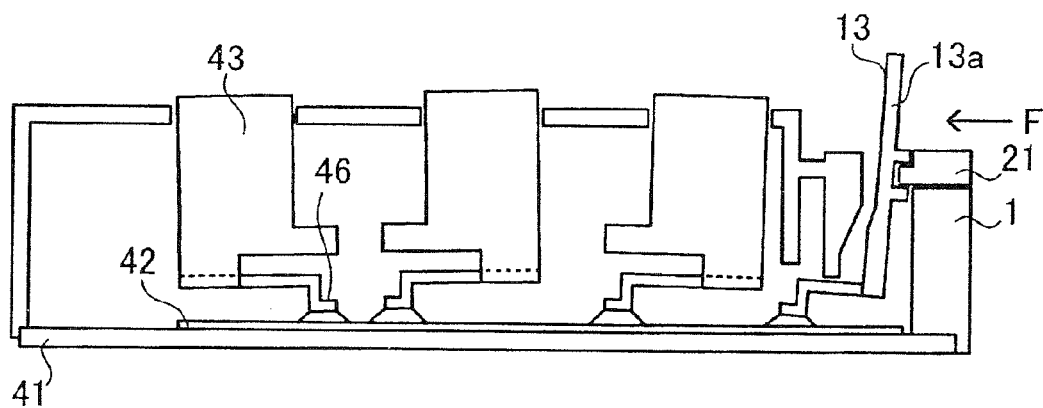


Fig. 18

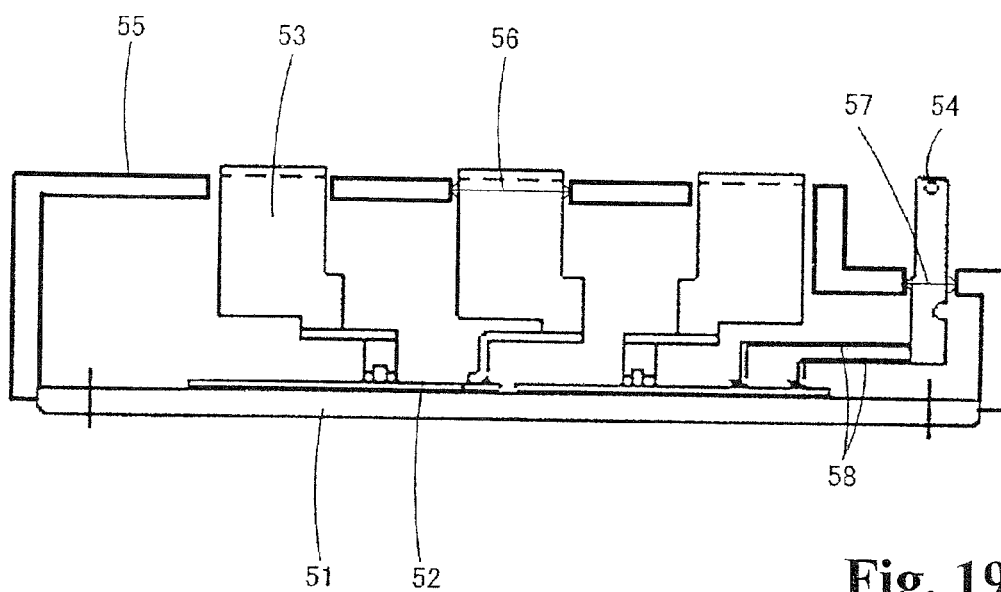


Fig. 19

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SEMICONDUCTOR DEVICE MANUFACTURING METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation application of Ser. No. 14/232,780, filed on Feb. 27, 2014, which is National Phase of International Application No. PCT/JP2012/071440 filed Aug. 24, 2012, and claims priority from Japanese Application No. 2011-183836 filed Aug. 25, 2011, which are incorporated by reference in its entirety

TECHNICAL FIELD

The present invention relates to a method of manufacturing a semiconductor device in which a control terminal can highly accurately be fixed to a resin case.

BACKGROUND ART

A conventional IGBT module has been known in which a main terminal and a control terminal, which are external lead terminals, are soldered onto a conductive pattern (circuit pattern) formed on an insulating substrate (referred hereinafter as “patterned insulating substrate”) (see Patent Document 1 below, for example). Patent Document 1 uses independent terminals as the external lead terminals. The independent terminals are not fixed to a resin case, wherein they are not insert-molded into a resin case. The independent terminals are electrically connected to external wiring by nut globes which are resin structures of nuts and nut receivers fitted together.

With the recent increase in the integration density of an IGBT module, the joint between the patterned insulating substrate and the external lead terminals of the package needs to be strong and reliable in the assembly of the IGBT module. In addition, the positions to dispose the external lead terminals of the package need to be precise when mounting the external lead terminals on the patterned insulating substrate. A configuration of a conventional IGBT module is now described with reference to FIG. 19.

FIG. 19 is a cross-sectional diagram showing the configurations of substantial parts of the conventional IGBT module with independent terminals. A main terminal 53 and a control terminal 54, which are the independent terminals, are soldered or welded to a patterned insulating substrate 52 which is fixedly attached onto a heat dissipating base 51. A resin case 55 is bonded to the rim of the heat dissipating base 51. The part of the heat dissipating base 51 that is near the patterned insulating substrate 52 is covered with the resin case 55. Openings 56, 57 are formed in this resin case 55, so that the main terminal 53 and the control terminal 54 are exposed to the outside of the resin case 55 through the openings 56, 57.

Patent Document 1: U.S. Pat. No. 6,597,585

A problem with the conventional IGBT module shown in FIG. 19 is that the control terminal 54 sinks into the resin case 55 when a compressive load is applied to the control terminal 54. In a case where the control terminal 54 is welded to the patterned insulating substrate 52 or the control terminal 54 is deformed very little, the patterned insulating substrate 52 can be damaged by a compressive load applied to the control terminal 54.

Another problem is that a tensile load applied to the control terminal 54 tears the joint between the control terminal 54 and the patterned insulating substrate 52, pulling the control terminal 54 out of the resin case 55. Because this conventional

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structure allows the control terminal 54 to move easily, it is difficult to highly accurately position and fix the control terminal 54 in the resin case 55. The control terminal 54 is deformed easily especially when the arm portion thereof is long, making an accurate positioning of the control terminal 54 more difficult.

DISCLOSURE OF THE INVENTION

In order to solve the problems of the prior art mentioned above, it is an object of the present invention to provide a semiconductor device in which a control terminal is prevented from moving up and down and can be fixed to a resin case, even when a compressive load or tensile load is applied to the control terminal, and a method of manufacturing such semiconductor device. In order to solve the problems of the prior art mentioned above, another object of the present invention is to provide a semiconductor device in which the position of the control terminal can be determined precisely, and a method of manufacturing the semiconductor device.

The semiconductor device according to the present invention has the following characteristics for the purpose of solving the foregoing problems and achieving the objects of the present invention. A control terminal is attached to a patterned insulating substrate. A first projection is formed on the control terminal. A second projection is formed on the control terminal away from the first projection. A concave is formed between the first projection and the second projection. A resin case having an opening for passing the control terminal therethrough is disposed to cover the patterned insulating substrate. A first concave portion is formed on a sidewall of the opening of the resin case. A beam portion is disposed at a bottom portion of the opening of the resin case. A second concave portion is formed in the beam portion. A resin block is inserted into the opening of the resin case and sandwiches the control terminal with the sidewall of the opening of the resin case to fix the control terminal to the resin case. A convex step portion to be fitted into the concave of the control terminal is formed in the resin block. A third projection to be fitted into the first concave portion is formed on a side surface of the resin block. A fourth projection to be fitted into the second concave portion is formed on a bottom surface of the resin block.

According to the foregoing invention, in the semiconductor device of the present invention, the bottom surface of the resin block and the beam portion may be fixed with an adhesive.

According to the foregoing invention, in the semiconductor device of the present invention, the beam portion may be provided with a liquid reservoir preventing the adhesive in a liquid state from flowing toward the control terminal.

The semiconductor device according to the present invention has the following characteristics for the purpose of solving the abovementioned problems and achieving the objects of the present invention. A control terminal is attached to a patterned insulating substrate. A resin case having an opening for passing the control terminal therethrough is disposed to cover the patterned insulating substrate. A first step portion is formed on the upper side of a sidewall of the opening of the resin case to project toward inside of the opening. A resin block is inserted into the opening of the resin case and sandwiches the control terminal with the sidewall of the opening of the resin case to fix the control terminal to the resin case. A convex second step portion is formed on a side surface of the resin block and has an inclined upper surface contacting the first step portion to fit.

The semiconductor device according to the present invention has the following characteristics for the purpose of solving

ing the abovementioned problems and achieving the objects of the present invention. A control terminal is attached to a patterned insulating substrate. A resin case having an opening for passing the control terminal therethrough is disposed to cover the patterned insulating substrate. A resin block is inserted into the opening of the resin case to contact a part of the control terminal and turning the part of the control terminal to a predetermined position to determine the position of the control terminal.

The method of manufacturing a semiconductor device according to the present invention is a method of manufacturing a semiconductor device including a control terminal attached to a patterned insulating substrate, and a resin case disposed to cover the patterned insulating substrate and has an opening for passing the control terminal therethrough. The method has the following characteristics for the purpose of solving the abovementioned problems and achieving the objects of the present invention. First, the control terminal is passed through the opening of the resin case to partially expose the control terminal from the opening, and the resin case is disposed to cover the patterned insulating substrate. Next, a resin block is inserted and installed in the opening of the resin case, and a convex step portion formed on a side surface of the resin block is fitted into a concave formed between two projections of the control terminal. A projection formed on the side surface of the resin block is fitted into a concave portion formed on a sidewall of the opening of the resin case. In addition, a projection formed on a bottom surface of the resin block is fitted into a concave portion formed in a beam portion at a bottom of the opening of the resin case. Consequently the control terminal, the resin case, and the resin block are fitted together, positioning and fixing the control terminal.

According to the foregoing invention, the method of manufacturing a semiconductor device may further include a step of applying an adhesive to the beam portion in order to bond the resin block to the resin case.

The method of manufacturing a semiconductor device according to the present invention is a method of manufacturing a semiconductor device including a control terminal attached to a patterned insulating substrate, and a resin case disposed to cover the patterned insulating substrate and has an opening for passing the control terminal therethrough. The method has the following characteristics for the purpose of solving the abovementioned problems and achieving the objects of the present invention. First, the method performs a step of covering the patterned insulating substrate with the resin case and passing a part of the control terminal through the opening of the resin case. Next, the method performs a step of determining the position of the control terminal by inserting a resin block into the opening of the resin case, contacting the resin block with a part of the control terminal, and turning the part of the control terminal to a predetermined position.

According to the foregoing invention, the method of manufacturing a semiconductor device according to the present invention resides in that the part of the control terminal is turned by the resin block until the control terminal contacts the sidewall of the opening of the resin case which is at a front in a direction of insertion of the resin block.

According to the foregoing invention, the method of manufacturing a semiconductor device according to the present invention resides in that an inclined upper surface of a convex step portion formed on a side surface of the resin block is fitted to a step portion projecting toward inside of the opening of the resin case on the upper side of the sidewall of the opening to fix the resin block to the resin case.

According to the present invention, because the two projections provided on a side end surface of the control terminal are fitted to the convex step portion of the resin block that is inserted into the opening of the resin case, the control terminal can be fixed to the resin case so as not to be moved by external force. Hence, even when external force such as a compressive load or tensile load is applied to the control terminal, the control terminal can be prevented from sinking into the resin case or being pulled out of the resin case.

Further, according to the present invention, as a result of holding the control terminal between the side surface of the resin block and the sidewall of the opening of the resin case and fitting the convex step portion of the resin block into the valley between the two projections of the control terminal, the control terminal can be fixed in place in the resin case. Thus, the position of the control terminal can be determined highly accurately.

The method of manufacturing the semiconductor device according to the present invention exerts the effect of fixing the control terminal to the resin case without causing vertical movement of the control terminal, even when a compressive load or tensile load is applied to the control terminal. The method of manufacturing the semiconductor device according to the present invention can also exert the effect of positioning the control terminal with a high degree of accuracy.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1(a)-1(d) are explanatory diagrams showing the configurations of substantial parts of a semiconductor device according to Embodiment 1 of the present invention.

FIGS. 2(a), 2(b) are explanatory diagrams showing the configurations of substantial parts near a control terminal of a resin case shown in FIGS. 1(a)-1(d).

FIGS. 3(a), 3(b) are explanatory diagrams showing the configurations of the control terminal shown in FIGS. 1(a)-1(d).

FIGS. 4(a)-4(c) are explanatory diagrams showing the configurations of a resin block for positioning and fixing the control terminal shown in FIGS. 1(a)-1(d).

FIGS. 5(a)-5(c) are explanatory diagrams showing the control terminal and resin block inserted in an opening of the resin case shown in FIGS. 2(a), 2(b).

FIG. 6 is an explanatory diagram showing an example of a method of inserting the resin block of FIGS. 1(a)-1(d) into the resin case.

FIGS. 7(a), 7(b) are explanatory diagrams showing a semiconductor device of Embodiment 2 of the present invention in process of manufacture.

FIGS. 8(a), 8(b) are explanatory diagrams showing the semiconductor device of Embodiment 2 of the present invention which is in a manufacturing step following the one shown in FIGS. 7(a), 7(b).

FIGS. 9(a), 9(b) are explanatory diagrams showing the semiconductor device of Embodiment 2 of the present invention which is in a manufacturing step following the one shown in FIGS. 8(a), 8(b).

FIGS. 10(a), 10(b) are explanatory diagrams showing the semiconductor device of Embodiment 2 of the present invention which is in a manufacturing step following the one shown in FIGS. 9(a), 9(b).

FIGS. 11(a), 11(b) are explanatory diagrams showing the configurations of substantial parts of a semiconductor device according to Embodiment 3 of the present invention.

FIGS. 12(a)-12(c) are explanatory diagrams showing the configurations of substantial parts of the semiconductor device according to Embodiment 3 of the present invention.

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FIG. 13 is an explanatory diagram showing the semiconductor device of Embodiment 3 of the present invention in process of manufacture.

FIG. 14 is an explanatory diagram showing the semiconductor device of Embodiment 3 of the present invention in process of manufacture.

FIG. 15 is an explanatory diagram showing the semiconductor device of Embodiment 3 of the present invention in process of manufacture.

FIG. 16 is an explanatory diagram showing the semiconductor device of Embodiment 3 of the present invention in process of manufacture.

FIG. 17 is an explanatory diagram showing the semiconductor device of Embodiment 3 of the present invention in process of manufacture.

FIG. 18 is an explanatory diagram showing the semiconductor device of Embodiment 3 of the present invention in process of manufacture.

FIG. 19 is a cross-sectional diagram showing the configurations of substantial parts of a conventional IGBT module with independent terminals.

BEST MODE FOR CARRYING OUT THE INVENTION

Preferred embodiments of a semiconductor device and a method of manufacturing the same according to the present invention are now described below in detail with reference to the accompanying drawings. In the following description of each embodiment and the accompanying drawings, like reference characters are used for indicating the same configurations, and therefore the overlapping explanations are omitted accordingly.

Embodiment 1

The configurations of the semiconductor device according to the present invention are described with reference to FIGS. 1(a) to 6. FIGS. 1(a)-1(d) are explanatory diagrams showing the configurations of substantial parts of a semiconductor device according to Embodiment 1 of the present invention. FIG. 1(a) is a top view of the semiconductor device 100 according to Embodiment 1. FIG. 1(b) is a side view taken along the line X-X of FIG. 1(a). FIG. 1(c) is a front view of a main terminal 43 which is viewed in the direction of the arrow A shown in FIG. 1(a). FIG. 1(d) is a cross-sectional diagram showing the detail of a rectangular section B shown in FIG. 1(b). This semiconductor device 100 is, for example, an IGBT module.

As shown in FIGS. 1(a)-1(d), the semiconductor device 100 has a resin case 1, a heat dissipating base 41, a patterned insulating substrate 42, a nut globe 45, a main terminal 43, a control terminal 13, and a resin block 21. The patterned insulating substrate 42 is fixedly attached to the heat dissipating base 41. The resin case 1 is bonded to the rim of the heat dissipating base 41 to cover the part of the heat dissipating base 41 which is near the patterned insulating substrate 42. The main terminal 43 and control terminal 13, the independent terminals led (connected) to the outside, are soldered or welded onto the patterned insulating substrate 42. The main terminal 43 and control terminal 13 are independent terminals which are not insert-molded to the resin case 1.

The main terminal 43 and control terminal 13 are exposed to the outside of the resin case 1 from an opening 44 and an opening 2, respectively, which are formed on an upper surface of the resin case 1. The main terminal 43 and control terminal are fixed by the nut globe 45 and the resin block 21, respec-

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tively. In particular, the main terminal 43 is in the shape of a reversed "U" in which the upper part (bottom part of the "U") is exposed to the outside of the resin case 1 from the opening 44 of the upper surface of the resin case 1. The two leg portions 46 of the main terminal 43 (the open ends of the "U") are soldered or welded to the patterned insulating substrate 42. The nut globe 45 is inserted between the two leg portions 46 of the main terminal 43 so as to go under the U-shaped curve of the main terminal 43 from the opening 44 formed on a side surface of the resin case 1 in order to fixate the main terminal 43.

The control terminal 13 is provided substantially upright on the patterned insulating substrate 42 and configured by an upright portion having its one end exposed to the outside of the resin case 1 and a coupled portion that is coupled to the other end of the upright portion to form a substantially L-shape together with the upright portion. One end of the coupled portion of the control terminal 13, opposite to an end of the same near the upright portion, is soldered or welded to the patterned insulating substrate 42 via a joint which is provided substantially upright on the patterned insulating substrate 42. A side end surface (simply referred to as "side end surface" hereinafter) 14 of the upright portion of the control terminal 13 is provided with first and second projections 16 and 17 and a concave valley 18 formed between the first projection 16 and the second projection 17. The resin block 21 is fitted into the valley 18 of the control terminal 13, thereby positioning and fixating the control terminal 13.

The configurations of the vicinity of the control terminal 13 of the resin case 1, the control terminal 13, and the resin block 21 are now described in detail. FIGS. 2(a), 2(b) are explanatory diagrams showing the configurations of substantial parts near the control terminal of the resin case shown in FIGS. 1(a)-1(d). FIG. 2(a) is a plan view of the resin case 1. FIG. 2(b) is a front view of the resin case 1, showing FIG. 2(a) in the direction of the arrow C. The resin case 1 has one opening 2 that is formed so as to be connected to the upper surface and side surface of the resin case 1. A beam portion 3 is formed in the bottom of this opening 2. First hood portions (first step portions) 8, convexed to project from either sidewall 5 of the opening 2 toward the inside of the opening 2, are formed on the upper side of either sidewall 5 of the opening 2.

A second hood portion (step portion) 9, convexed to project toward the inside of the opening 2, is formed on a front sidewall of the opening 2. The front sidewall of the opening 2 is a sidewall positioned to face the mouth of the opening 2, which is located near the side surface of the resin case 1. First concave portions 6 are formed on either sidewall of the opening 2 so as to extend to the outside of the opening 2. The first concave portions 6 are disposed away from the first hood portions 8. A second concave portion 7 is formed in the beam portion 3 so as to extend downward (toward the heat dissipating base 41). In addition, a through-hole 4, through which the control terminal 13 is passed, is formed in the beam portion 3. Further, a third concave portion 10 and liquid reservoirs 11 are formed in the beam portion 3. An adhesive, not shown, is dropped (or applied) onto the third concave portion 10. The liquid reservoirs 11 prevent the adhesive from flowing toward the control terminal 13.

FIGS. 3(a), 3(b) are explanatory diagrams showing the configuration of the control terminal shown in FIGS. 1(a)-1(d). FIG. 3(a) is a side view of the control terminal 13. FIG. 3(b) is a top view of the control terminal 13. The two projections, the first and second projections 16 and 17, are formed side by side on the side end surface 14 of the control terminal 13. The side end surface 14 of the control terminal 13 also has the valley 18 formed between the first and second projections

16 and 17. As will be described below, a front end 27 of a convex step portion (second step portion) 26, formed on each side surface 22 of the resin block 21, is fitted into the valley 18. Reference numeral 15 shown in FIGS. 3(a), 3(b) represents a flat plate configuring the upright portion of the control terminal 13 (simply referred to as "flat plate" hereinafter). The front end 27 of the step portion 26 faces the side end surface 14 of the control terminal 13 after assembly of the semiconductor device 100. Reference numerals 13a to 13c represent the upright portion, coupled portion, and joint of the control terminal 13, respectively.

FIGS. 4(a)-4(c) are explanatory diagrams showing a configuration of the resin block by which the control terminal shown in FIGS. 1(a)-1(d) are positioned and fixated. FIG. 4(a) is a top view of the resin block 21. FIG. 4(b) is a bottom view of the resin block 21. FIG. 4(c) is a side view of the resin block 21. Third projections 23 are formed on each of the side surfaces 22 of the resin block 21. A fourth projection 25 is formed on a bottom surface 24 of the resin block 21. The convex step portion 26 is formed on each side surface 22 of the resin block 21.

The convex step portion 26 is formed on the lower side of each side surface 22 of the resin block 21, at a rear end of the resin block 21. The rear end of the resin block 21 is positioned at the mouth of the opening 2 on the side surface of the resin case 1 after assembly of the semiconductor device 100. A concave groove 29 is formed at a front end 28 of the resin block 21. The front end 27 of the convex step portion 26 is fitted into the valley 18 formed between the first and second projections 16 and 17 of the control terminal 13. The front end 28 of the resin block 21 is positioned to face the front sidewall of the opening 2 of the resin case 1 after assembly of the semiconductor device 100.

FIGS. 5(a)-5(c) are explanatory diagrams showing the control terminal and resin block inserted and installed in the opening of the resin case shown in FIGS. 2(a), 2(c). FIG. 5(a) is a plan view showing the control terminal 13 and the resin block 21 inserted and installed in the opening 2 of the resin case 1. FIG. 5(b) is a front view viewed in the direction of the arrow D shown in FIG. 5(a). FIG. 5(c) is a cross-sectional diagram showing the front end 27 of the convex step portion 26 on each side surface 22 of the resin block 21 fitted into the valley 18 formed between the first and second projections 16 and 17 of the control terminal 13.

The flat plate 15 of the control terminal 13 is pressed by each sidewall 5 of the opening 2 of the resin case 1 and each side surface 22 of the resin block 21, thereby fixing the control terminal 13 in place in a direction perpendicular to the direction of the arrow D (a direction perpendicular to the flat plate 15 of the control terminal 13). The front end 27 of the convex step portion 26 on each side surface 22 of the resin block 21 is fitted into the valley 18 formed between the first and second projections 16 and 17 of the control terminal 13, thereby fixing the control terminal 13 in place in the direction of the arrow D. In this manner, the control terminal 13 can be positioned and fixed accurately by pressing the flat plate 15 and side end surface 14 of the control terminal 13 using the sidewall 5 of the opening 2 of the resin case 1 and the resin block 21.

A method of manufacturing the semiconductor device 100 shown in FIGS. 1(a)-1(d) is described next. As shown in FIGS. 1(a)-1(d), after soldering the patterned insulating substrate 42 onto the heat dissipating base 41, the main terminal 43 and the control terminal 13, which are the independent terminals, are soldered onto the patterned insulating substrate 42. In particular, the two leg portions 46 of the main terminal

43 are soldered to the patterned insulating substrate 42. The joint of the control terminal 13 is soldered to the patterned insulating substrate 42.

The patterned insulating substrate 42 is then covered by the resin case 1 in such a manner that the upper surface of the main terminal 43 and the upper part of the control terminal 13 are exposed to the outside of the resin case 1, and then the lower part of the resin case 1 is bonded to the rim of the heat dissipating base 41. Thereafter, the nut globe 45 is inserted and installed so as to go under the main terminal 43 from the opening 44 provided on the side surface of the resin case 1. The nut globe 45 is a resin structure of a nut and a nut receiver fitted together and is in the shape of, for example, a cuboid (a rod-like cuboid). The nut is fitted into the nut receiver so as to be capable of moving vertically freely in the nut receiver.

The main terminal 43 is in the shape of a reversed "U" as shown in FIG. 1(c), and the nut globe 45 is inserted and installed so as to go under the U-shaped curve of the main terminal 43. The upper part of this main terminal 43 is exposed to the outside of the resin case 1. A mounting hole to be mounted on external wiring is formed in the upper part of the main terminal 43 which is exposed to the outside of the resin case 1. Then, the control terminal 13 shown in FIGS. 3(a), 3(b) is inserted into each through-hole 4 at the bottom of the opening 2 of the resin case 1 shown in FIGS. 2(a), 2(b), and the resin block 21 shown in FIGS. 4(a)-4(c) is inserted and installed in a lateral direction from the opening 2 on either side surface of the resin case 1, to accurately position and fix the control terminal 13. The lateral direction here means a direction parallel to a main surface of the patterned insulating substrate 42.

At this moment, the front end 27 of the convex step portion 26 on each side surface 22 of the resin block 21 is fitted into the valley 18 between the first and second projections 16 and 17 of the control terminal 13. Hence, the front end 27 of the convex step portion 26 on each side surface 22 of the resin block 21 is hooked on the second projection 17 when a compressive load is applied to the control terminal 13, and on the first projection 16 when a tensile load is applied to the same. This can prevent the control terminal 13 from sinking into the resin case 1 or being pulled out of the resin case 1.

Because the flat plate 15 and side end surface 14 of the control terminal 13 are held between the opening 2 of the resin case 1 and the resin block 21, the control terminal 13 is positioned and fixed in the resin case 1, as accurately as the external lead terminals that are insert-molded into the resin case 1. Moreover, even when the control terminal 13 is deformed, holding the flat plate 15 and side surface 14 of the control terminal 13 between the opening 2 of the resin case 1 and the resin block 21 can correct the deformation.

When the resin block 21 is inserted into the opening 2 of the resin case 1, the third projections 23 on either side surface 22 of the resin block 21 and the fourth projection 25 on the bottom surface 24 of the resin block 21 are fitted into the first concave portions 6 of the sidewalls 5 of the opening 2 of the resin case 1 and the second concave portion 7 of the beam portion 3 at the bottom of the opening 2 of the resin case 1, respectively. As a result, the resin block 21 can accurately be positioned and fixed in the resin case 1.

When the resin block 21 is inserted into the opening 2 of the resin case 1, the convex step portion 26 that is formed on the lower side of each side surface 22 of the resin block 21 is fitted under the first hood portion 8 formed on the upper side of the opening 2 of the resin case 1. In addition, the second hood portion 9 that is formed on the front sidewall of the opening 2 of the resin case 1 is fitted into a concave groove 29 formed at the front end 28 of the resin block 21. This further fixes the

resin block **21** to the resin case **1**. The term “front” indicates the direction in which the resin block **21** is inserted from the opening **2** on each side of the resin case **1**. The upper and front surfaces of the resin block **21** that are fitted into the resin case **1** are exposed from the resin case **1**.

Further, the bottom surface **24** of the resin block **21** and the beam portion **3** at the bottom of the opening **2** of the resin case **1** are fixed by an adhesive which is not shown. The beam portion **3** is provided with a liquid reservoir **11**, a groove for catching a liquid adhesive so that it does not flow to the control terminal **13** prior to the fixation, as shown in FIGS. **2(a)**, **2(b)**. The third concave portion **10** is formed in the center of the beam portion **3** in which the liquid adhesive is disposed, and a fifth projection **30** on the bottom surface **24** of the resin block **21** is fitted into the third concave portion **10**.

In this manner, stronger fixation between the resin case **1** and the resin block **21** can be realized by fitting and bonding the resin case **1** and the resin block **21** to each other by means of the adhesive.

As described above, the control terminal **13** can accurately be positioned and fixed in the resin case **1** by inserting the front end **27** of the convex step portion **26** of the resin block **21** into the valley **18** formed between the first and second projections **16** and **17** of the control terminal **13**. This can consequently prevent the control terminal **13** from sinking into the resin case **1** when a compressive load is applied to the control terminal **13**. The control terminal **13** can also be prevented from being pulled out of the resin case **1** when a tensile load is applied to the control terminal **13**.

The side surfaces **22** and the bottom surface **24** of the resin block **21** are provided respectively with the third projections **23** and the fourth projection **25**, and the sidewalls **5** and the beam portion **3** of the opening **2** of the resin case **1** are provided respectively with the first concave portions **6** and the second concave portion **7**. Fitting the third projections **23** into the first concave portions **6** and the fourth projection **25** into the second concave portion **7** can prevent the resin block **21** from being removed from the resin case **1**.

When the plurality of control terminals **13** is joined to the patterned insulating substrate **42**, the semiconductor device **100** may have the resin case **1** having as many openings **2** as the number of the control terminals **13** and as many resin blocks **21** as the number of the openings **2** of the resin case **1**. In this case, for example, the resin blocks **21** may be inserted into the openings **2** of the resin case **1**, respectively. FIG. **6** is an explanatory diagram showing an example of a method of inserting the resin block of FIGS. **1(a)**-**1(d)** into the resin case. An example in which the semiconductor device **100** has the resin case **1** with two openings **2** (openings **2a**, **2b**, hereinafter) and two resin blocks **21** (resin blocks **21a**, **21b**, hereinafter) is now described.

As shown in FIG. **6**, upon resin-molding of the resin blocks **21a**, **21b**, the resin blocks **21a**, **21b** are previously connected to each other by means of a connector **31** leaving therebetween a space equal to the space between the openings **2a**, **2b** of the resin case **1**. After inserting and installing the resin blocks **21a**, **21b** into the openings **2a**, **2b** of the resin case **1**, the connector **31** (also referred to as “runner”) is cut, for example, at the positions of the dashed lines **32** near the openings **2a**, **2b** of the resin case **1**, thereby removing the connector **31**. By inserting the resin blocks **21a**, **21b** into the openings **2a**, **2b** of the resin case **1** in the manner described above, the resin blocks **21a**, **21b** can be inserted and installed efficiently into the resin case **1**, improving the ease of assembly of the semiconductor device **100**.

Furthermore, increasing the size of the third projections **23** on the side surfaces **22** of the resin block **21** shown in FIGS.

1(a)-**1(d)** can improve the fitting between the resin block **21** and the resin case **1**. Hence, the resin block **21** can accurately be fixed to the resin case **1** without using an adhesive. In so doing, the fourth projection **25** is not necessarily formed on the bottom surface **24** of the resin block **21**.

Although the main terminal **43** and the control terminal **13** are described as the independent terminals in Embodiment 1, the main terminal **43** is not necessarily an independent terminal.

Embodiment 2

The method of manufacturing a semiconductor device according to the present invention is now described in detail. FIGS. **7(a)** to **10(b)** are each an explanatory diagram showing a semiconductor device of Embodiment 2 of the present invention in process of manufacture. The method of manufacturing a semiconductor device according to Embodiment 2 is a method of manufacturing the semiconductor device **100** of Embodiment 1 shown in FIGS. **1(a)** to **6**. Throughout FIGS. **7(a)** to **10(b)**, (a) is a cross-sectional diagram showing the entire semiconductor device **100**, and (b) is an enlarged plan view showing the area near the control terminal **13**.

As shown in FIGS. **7(a)**, **7(b)**, a semiconductor chip (not shown), the main terminal **43**, and the control terminal **13** are fixated onto the patterned insulating substrate **42** by means of soldering (or sometimes welding), the patterned insulating substrate **42** being fixated onto the heat dissipating base **41**. Next, the resin case **1** is installed so as to cover the patterned insulating substrate **42**. The main terminal **43** is exposed from the upper side of the opening **44** of the resin case **1**, and the control terminal **13** is passed through the through-hole **4** formed in the bottom of the opening **2**. Subsequently, the lower part of the resin case **1** is bonded to the rim of the heat dissipating base **41**. The nut globe **45** is then passed under the main terminal **43** so as to be fixed to the resin case **1**.

Next, as shown in FIGS. **8(a)**, **8(b)**, a liquid adhesive **47a** is dropped (or applied) onto the third concave portion **10** which is formed in the beam portion **3** provided in the bottom of the opening **2** of the resin case **1**.

Next, the resin block **21** is inserted and installed in the opening **2** of the resin case **1**, as shown in FIGS. **9(a)**, **9(b)**. In so doing, the front end **27** of the convex step portion **26** on each side surface **22** of the resin block **21** is fitted into the valley **18** formed between the first and second projections **16** and **17** (two projections) of the control terminal **13**. The third projections **23** of the resin block **21** are fitted into the first concave portions **6** formed on the sidewalls **5** of the opening **2** of the resin case **1**, and the fourth projection **25** of the resin block **21** is fitted into the second concave portion **7** formed in the beam portion **3** in the bottom of the opening **2** of the resin case **1**, thereby positioning and fixing the control terminal **13** in the resin case **1**.

Thereafter, as shown in FIGS. **10(a)**, **10(b)**, the liquid adhesive **47a** in the third concave portion **10** is solidified, to fix the beam portion **3** at the bottom of the opening **2** of the resin case **1** to the bottom surface **24** of the resin block **21** further rigidly. The resin block **21** may simply be fitted into the resin case **1** without using the adhesive **47**.

Embodiment 3

Another configuration of the semiconductor device of the present invention is now described as Embodiment 3 with reference to FIGS. **11(a)**, **11(b)** and **12(a)**-**12(c)**. FIGS. **11(a)**, **11(b)** and **12(a)**-(c) are each an explanatory diagram showing the configurations of substantial parts of a semiconductor

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device according to Embodiment 3 of the present invention. The semiconductor device according to Embodiment 3 is a modification of the semiconductor device of Embodiment 1 shown in FIGS. 1(a) to 6. FIGS. 11(a), 11(b) show the other configurations of substantial parts near the control terminal of the resin case shown in FIG. 1. FIG. 11(a) is a plan view of the resin case 1. FIG. 11(b) is a front view of the resin case 1, showing FIG. 11(a) in the direction of the arrow E. FIGS. 12(a)-12(c) show the other configurations of the resin block by which the control terminal shown in FIGS. 1(a)-1(d) is positioned and fixed. FIG. 12(a) is a plan view of the resin block 21. FIG. 12(b) is a bottom view of the resin block 21. FIG. 12(c) is a side view of the resin block 21.

The semiconductor device of Embodiment 3 shown in FIGS. 11(a), 11(b) and 12(a)-12(c) is different from the semiconductor device of Embodiment 1 in that the resin block 21 is fitted into the openings 2 of the resin case 1 by press-fitting the resin block 21 into the openings 2 of the resin case 1 without using an adhesive. In particular, upper surfaces 26a of the convex step portions 26 on the side surfaces 22 of the resin block 21 are inclined downward from rear ends of the step portions 26 toward the front ends 27.

By taking advantage of the inclined upper surfaces 26a of the step portions 26, the front ends 27 of the step portions are prevented from contacting the first hood portions 8 formed on the upper side of the sidewalls 5 of the opening 2 of the resin case 1, when the resin block 21 is inserted into the opening 2 of the resin case 1. Due to such a configuration, the resin block 21 can easily be inserted into the opening 2 of the resin case 1.

Because the upper surfaces 26a of the step portions 26 are inclined so that the level of the rear ends of the step portions 26 is higher than that of the front ends 27, the upper surfaces 26a of the step portions 26 can be fitted in contact with the first hood portions 8 by press-fitting the resin block 21 into the opening 2 of the resin case 1 until the resin block 21 stops. As a result, the resin block 21 is fixed in place in the insertion direction (lateral direction) thereof. Due to the downward force applied from the resin case 1 to the resin block 21, the vertical position of the resin block 21 is determined. As with Embodiment 1, the third projections 23 formed on the side surfaces 22 of the resin block 21 are fitted into the first concave portions 6 on the sidewalls 5 of the opening 2 of the resin case 1, thereby fixing the resin block 21 in place in the direction (lateral direction) perpendicular to the insertion direction. Determining the vertical and lateral position of the resin block 21 in this manner can prevent the resin block 21 from being removed from the opening 2 of the resin case 1.

Further, as a result of press-fitting the resin block 21 into the opening 2 of the resin case 1 until the resin block 21 stops, the upright portion 13a of the control terminal 13 is turned inward by the resin block 21 and consequently fixed in contact with the front sidewall of the opening 2 of the resin case 1. Thus, the position of the control terminal 13 can be grasped based on the front sidewall of the opening 2 of the resin case 1. Even when the control terminal 13 joined to the patterned insulating substrate 42 is inclined toward the outside, the position of the control terminal 13 can be corrected by the resin block 21, improving the position accuracy of the control terminal 13. The configurations of the elements other than the upper surfaces 26a of the step portions 26 of the semiconductor device according to Embodiment 3 are the same as those of the semiconductor device shown in FIGS. 1(a) to 6.

In Embodiment 3, the resin block 21 can be fitted into the opening 2 of the resin case 1 without using an adhesive. This means that the third concave portion onto which an adhesive is dropped (or applied), the liquid reservoir for preventing the

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adhesive from flowing toward the control terminal, and the fifth projection on the bottom surface 24 of the resin block 21, are not required. Also, because the vertical movement of the resin block 21 can be inhibited by inclining the upper surfaces 26a of the step portions 26, neither the second concave portion on the lower side of the beam portion 3 of the resin block 21 nor the fourth projection on the bottom surface 24 of the resin block 21 is required. When the fourth and fifth projections are not provided on the bottom surface 24 of the resin block 21, it is not necessary to take into consideration the heights of the fourth and fifth projections to increase the width of the opening 2 of the resin case 1 in the thickness direction. Thus, the gap between the opening 2 of the resin case 1 and the resin block 21 in the thickness direction can be reduced.

A method of manufacturing the semiconductor device shown in FIGS. 11(a), 11(b) and 12(a)-12(c) is described next. FIGS. 13 to 18 are each an explanatory diagram showing the semiconductor device of Embodiment 3 of the present invention in process of manufacture. The heat dissipating base 41, made of copper (Cu), becomes thermally expanded and deformed as a result of being solder-jointed to the patterned insulating substrate 42. For this reason, the heat dissipating base 41 is curved to the back into a convex shape beforehand in consideration of the fact that it deforms due to thermal expansion.

Next, the patterned insulating substrate 42 such as a ceramic insulating substrate (DCB substrate) is joined to the front surface of the heat dissipating base 41 via a solder-joint layer, not shown, therebetween, the heat dissipating base 41 being curved to the back into a convex shape. Because the heat dissipating base 41 is deformed beforehand in consideration of the fact that it deforms due to thermal expansion as described above, solder-joining the patterned insulating substrate 42 to the heat dissipating base 41 as shown in FIG. 14 eliminates the curve of the heat dissipating base 41 and makes it flat.

Next, the control terminal 13 and the main terminal 43 are soldered or welded to the circuit pattern of the patterned insulating substrate 42. The control terminal 13 and the main terminal 43 are normally joined at a temperature of approximately 260° C. However, since the melting point of solder is approximately 240° C., the solder joint layer joining the heat dissipating base 41 and the patterned insulating substrate 42 together might melt as a result of soldering or welding the control terminal 13 and the main terminal 43.

When the solder-joint layer for joining the heat dissipating base 41 and the patterned insulating substrate 42 melts, the heat dissipating base 41 returns to its initial state when it is deformed to the back into a convex shape, as shown in FIG. 15. Therefore, the control terminal 13 and the main terminal 43 are soldered or welded to the patterned insulating substrate 42 curved to the back into a convex shape, perpendicularly to, for example, a stage on which the heat dissipating base 41 is placed, as in the case where the patterned insulating substrate 42 is flat.

Thereafter, the solder-joint layer between the heat dissipating base 41 and the patterned insulating substrate 42 is cooled and solidified. The heat dissipating base 41 and the patterned insulating substrate 42 are consequently joined to each other again by the solder-joint layer, resulting in the elimination of the curve of the heat dissipating base 41 and making the heat dissipating base 41 and the patterned insulating substrate 42 flat. However, the control terminal 13 is joined to the patterned insulating substrate 42 when the patterned insulating substrate 42 is curved to the back into a convex shape, as described above. This means that, as shown in FIG. 16, the control terminal 13 is inclined to the outside after the curve of

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the heat dissipating base **41** and patterned insulating substrate **42** is eliminated. Consequently, the upper end of the control terminal **13** (the end that is exposed to the outside of the resin case **1**) is shifted toward the outside.

Next, as shown in FIG. **17**, the resin case **1** is bonded to the rim of the patterned insulating substrate **42** so as to cover the patterned insulating substrate **42**. In this case, the main terminal **43** is exposed from the upper side of the opening **44** of the resin case **1**, and the control terminal **13** is passed through the through-hole **4** formed in the bottom of the opening **2**. For the purpose of clearly illustrating the control terminal **13**, a simplified resin case **1** is shown in FIG. **17** (in FIG. **18** as well).

As shown in FIG. **18**, the resin block **21** is inserted into the opening **2** of the resin case **1** so the front end **27** of the convex step portion **26** on each side surface **22** of the resin block **21** is fitted into the valley **18** formed between the first and second projections **16** and **17** of the control terminal **13**. The resin block **21** is pressed into the opening **2** of the resin case **1** until the resin block **21** stops. Consequently, the upright portion **13a** of the control terminal **13** is turned by the resin block **21** in the direction indicated by the arrow **F**, and the surface of the control terminal **13**, opposite to the side end surface **14**, contacts the front sidewall of the opening **2** of the resin case **1**. As a result, the control terminal **13** is held by the front sidewall of the opening **2** of the resin case **1** and the front ends **27** of the resin block **21**. The flat plate **15** of the control terminal **13** is also held by the sidewalls **5** of the opening **2** of the resin case **1** and the side surfaces **22** of the resin block **21**.

The inclined upper surfaces **26a** of the convex step portions **26** formed on the lower side of the side surfaces **22** of the resin block **21** are brought into contact with and fitted into the first hood portions **8** on the upper side of the opening **2** of the resin case **1**, by press-fitting the resin block **21** into the opening **2** of the resin case **1**. Within the opening **2** of the resin case **1**, the third projections **23** on the side surfaces **22** of the resin block **21** are fitted into the first concave portions **6** which are formed on the sidewalls **5** of the opening **2** of the resin case **1**. The resin block **21** is, therefore, fixed to the resin case **1** completely, and as a result the control terminal **13** is fixed in place in the lateral direction. Subsequently, the main terminal **43** is fixed by the nut globe **45** as shown in FIG. **1(b)**, completing the semiconductor device according to Embodiment 3.

According to each of the embodiments described above, by fitting the first and second projections of the side end surfaces of the control terminal to the convex step portions of the resin block inserted into the opening of the resin case, the control terminal can be fixed to the resin case so as not to be shifted by external force. Thus, even when external force such as a compressive load or tensile load is applied to the control terminal, the control terminal can be prevented from sinking into the resin case or being pulled out of the resin case.

In addition, according to the foregoing embodiments, the control terminal is fixed in place in the resin case by holding the control terminal between the side surfaces of the resin block and the sidewalls of the opening of the resin case and then fitting the convex step portions of the resin block into the valley between the first and second projections of the control terminal. This can accurately determine the position of the control terminal.

According to Embodiment 3, press-fitting the resin block into the opening of the resin case until the resin block stops, not only fixes the control terminal between the resin case and the resin block, but also determines the vertical and lateral position of the resin block. This can prevent the resin block from being removed from the opening of the resin case and fix the control terminal in place in the resin case. According to

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Embodiment 3, even when the control terminal that is bonded to the patterned insulating substrate is tilted to the outside, the control terminal can contact the front sidewall of the opening of the resin case by turning the upright portion of the control terminal inward by means of the resin block. Therefore, even when the control terminal that is bonded to the patterned insulating substrate is tilted to the outside, the control terminal can be fixed in place in the resin case so the position of the control terminal can be grasped accurately.

The present invention can be applied not only to each of the foregoing embodiments but also to semiconductor devices of various configurations. The present invention is described herein with an example in which the side end surface of the control terminal is provided with two projections and one valley therebetween, but the side end surface of the control terminal may be provided with three or more projections.

INDUSTRIAL APPLICABILITY

As described above, the semiconductor device and the method of manufacturing the same according to the present invention are useful in a module semiconductor device in which an external lead terminal of a package is mounted on a patterned insulating substrate.

EXPLANATION OF REFERENCE NUMERALS

- 1** Resin case
- 2, 2a, 2b** Opening for inserting control terminal
- 3** Beam portion
- 4** Through-hole
- 5** Sidewall of opening
- 6** First concave portion
- 7** Second concave portion
- 8** First hood portion
- 9** Second hood portion
- 10** Third concave portion
- 11** Liquid reservoir
- 13** Control terminal
- 13a** Upright portion of control terminal
- 13b** Coupled portion of control terminal
- 13c** Joint of control terminal
- 14** Side end surface
- 15** Flat plate
- 16** First projection
- 17** Second projection
- 18** Valley
- 21, 21a, 21b** Resin block
- 22** Side surface of resin block
- 23** Third projection
- 24** Bottom surface of resin block
- 25** Fourth projection
- 26** Convex step portion on side surface of resin block
- 26a** Inclined upper surface of convex step portion on side surface of resin block
- 27** Front end of convex step portion
- 28** Front end of resin block
- 29** Concave groove of resin block
- 30** Fifth projection (fitted into concave portion **10**)
- 31** Connector
- 32** Dotted line near opening of resin case
- 41** Heat dissipating base
- 42** Patterned insulating substrate
- 43** Main terminal
- 44** Opening for inserting main terminal
- 45** Nut globe
- 46** Legs of main terminal

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47 Adhesive

47a Liquid adhesive

47b Solidified adhesive

What is claimed is:

1. A method of manufacturing a semiconductor device including a control terminal attached to a patterned insulating substrate, and a resin case disposed to cover the patterned insulating substrate and having an opening for passing the control terminal therethrough, the method comprising the steps of:

passing the control terminal through the opening of the resin case to partially expose the control terminal from the opening and covering the patterned insulating substrate with the resin case; and

inserting a resin block in the opening of the resin case, fitting a convex step portion formed on a side surface of the resin block into a concave portion formed between two projections of the control terminal, fitting a projection formed on the side surface of the resin block into a concave portion formed on a sidewall of the opening of the resin case, and fitting a projection formed on a bottom surface of the resin block into a concave portion formed in a beam portion at a bottom portion of the opening of the resin case to position and fix the control terminal.

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2. The method according to claim 1, further comprising a step of applying an adhesive to the beam portion to bond the resin block to the resin case.

3. A method of manufacturing a semiconductor device including a control terminal attached to a patterned insulating substrate, and a resin case disposed to cover the patterned insulating substrate and having an opening for passing the control terminal therethrough, the method comprising the steps of:

covering the patterned insulating substrate with the resin case and passing a part of the control terminal through the opening of the resin case; and

determining a position of the control terminal by inserting a resin block into the opening of the resin case, and contacting the resin block with a part of the control terminal and turning the part of the control terminal to a predetermined position.

4. The method according to claim 3, wherein the part of the control terminal is turned by the resin block until the control terminal contacts a sidewall of the opening of the resin case which is at a front in an insertion direction of the resin block.

5. The method according to claim 3, wherein an inclined upper surface of a convex step portion formed on a side surface of the resin block is fitted to a step portion projecting toward inside of the opening of the resin case on an upper side of a sidewall of the opening to fix the resin block to the resin case.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 9,136,225 B2
APPLICATION NO. : 14/703313
DATED : September 15, 2015
INVENTOR(S) : Yoshihiro Kodaira

Page 1 of 1

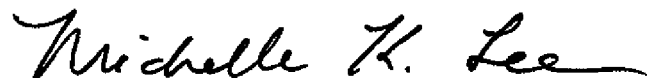
It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Specification

Please change column 5, line 66, from "... control terminal" to --... control terminal 13--.

Please change column 11, line 24, from "... step portions are" to --... step portions 26 are--.

Signed and Sealed this
Second Day of February, 2016



Michelle K. Lee
Director of the United States Patent and Trademark Office